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RARE VASCULAR PLANT SPECIES OF THE CENTENNIAL VALLEY/MOUNTAINS REGION, BEAVERHEAD COUNTY, MONTANA

I. Introduction

Within the Centennial Valley/Mountains Region, a tremendous diversity of microenvironments is represented. This diversity is a result of the wide range of elevational, climatic and topographic variation in the area, as well as the presence of a number of different soil parent materials. These microenvironments include: open sagebrush desert and scabland; open, rocky canyons and streambanks; open, somewhat disturbed roadways and trails; dry, open grasslands; seasonally moist, montane coniferous forests; seasonally moist aspen groves; moist stream courses; montane and subalpine meadows and slopes; subalpine and alpine lakes; subalpine and alpine coniferous forests; alpine scree and talus slopes, meadows, grasslands, and windswept ridges; a wide range of wetland habitats including lakes, ponds, wet meadows, marshes, and seepage areas; and sand dunes and hills (Lesica, 1984a; Lowry, 1979).

One striking result of such microenvironment diversity is a high number of vascular plant taxa, and several floristic studies in the region have documented this diversity. In a Bureau of Land Management study in the Centennial Mountains, Lowry (1979) lists 362 taxa (including species, subspecies, and varieties) representing 190 genera in 43 families; this is approximately 15% of the flora of Montana. Dorn (1968), in a broader study of the Red Rock Lakes National Wildlife Refuge and the adjacent Centennial Mountains, lists 487 species in 243 genera and 65 families (approximately 21% of the state's flora). Such high floristic diversity in a comparatively small area is always of phytogeographic interest.

Areas of such high floristic and geographic diversity often harbor numerous rare or unique species, and this is the case in the Centennial Region. Although there are no taxa known to be strictly endemic to the Region, a number of taxa occur there which are either regional endemics, or which occur on the edge of their range in this portion of Montana. The following list of rare taxa, which occur in the Centennial Region, indicates those which are considered to be of special concern in Montana by the Natural Heritage Program.

II. Specific information

The following list should be prefaced with the statement that, although some floristic exploration has been done in the Region, there is a remaining need for further inventory work. Currently there are no data relating to the population trends of these taxa, and in some cases (i.e., records from older herbarium

collections) exact location information is also lacking. A brief summary of current knowledge for each taxon is provided.

1. Allium acuminatum Hook. (Liliaceae)--Tapertip onion
Distribution:
Region: Unknown, species reported by Lowry (1979); peripheral.
Montana: Beaverhead and Ravalli Cos.
Global: BC, WA and OR, to sw. MT, s. WY, w. CO, AZ, and n. CA.
Phenology/Growth Form: Flowering May-July, fruiting June-August; perennial graminoid.
Habitat: Dry, open hills and plains to subalpine slopes, at middle-high elevations.
Management threats/needs: Unknown.

2. Astragalus ceramicus Sheld. var. apus Barneby (Fabaceae)--Painted milk-vetch
Distribution:
Region: Sandhills of the northcentral Centennial Valley; regional endemic.
Montana: Known only from the Centennial Valley, Beaverhead Co.
Global: Also known from Butte Co., e. to w. Madison, nw. Bonneville, and Fremont Cos., Idaho.
Phenology/Growth Form: Flowering May-July, fruiting June-August; perennial forb.
Habitat: Sand hills, dunes, and flats, ca. 4400-4800 ft.
Management threats/needs: Possibly threatened by livestock grazing.

3. Astragalus terminalis Wats. (Fabaceae)--Railhead milk-vetch
Distribution:
Region: Sheep Mountain area, from low elevations to the mountain crest; regional endemic.
Montana: Beaverhead and Red Rock River valleys, Beaverhead Co.
Global: Sw. MT, s. to Custer Co., ID, s. and e. to Teton Co., WY.
Phenology/Growth Form: Flowering June-August, the fruit long persisting; perennial forb.
Habitat: Stony or grassy hillsides, talus, and rocky benchlands, often in sagebrush, on limestone (or reportedly on rhyolite), 5300-10300 ft. (Barneby, 1964).
Management threats/needs: Possibly threatened by livestock and/or sheep grazing.

4. Carex multicostata Mack. (Cyperaceae)--Many-ribbed sedge
Distribution:
Region: U.S. Sheep Experiment Station area, Odell Creek and Taylor Mountain; peripheral.

Montana: Gallatin and s. Beaverhead Cos.
Global: MT to WA, s. to CA and NV.
Phenology/Growth Form: Flowering and fruiting June-August; rhizomatous perennial graminoid.

Habitat: Moist to dry meadows, streambanks, and open, moist slopes at moderate elevations, occasionally ascending to near timberline (Hitchcock et al., 1969).
Management threats/needs: Unknown, though the species may tolerate grazing to a certain extent (Hermann, 1970).

5. Carex vallicola Dewey (Cyperaceae)--Valley sedge
Distribution:
Region: Unknown, species reported by Dorn (1968); peripheral.
Montana: Beaverhead Co.
Global: Central OR to c. ID, extreme sw. MT, WY, and SD, s. to CA, UT, and Mexico.
Phenology/Growth Form: Flowering and fruiting April-July; rhizomatous perennial graminoid.
Habitat: Foothills to midmontane, often with sagebrush or aspen; reported from grassland habitat by Dorn (1968).
Management threats/needs: Unknown.

6. Castilleja gracillima Rydb. (Scrophulariaceae)--Slender paintbrush
Distribution:
Region: Unknown, species reported by Lowry (1979); peripheral.
Montana: Gallatin, Madison, and s. Beaverhead Cos.
Global: Nw. WY and adjacent MT, to c. ID and possibly e. BC.
Phenology/Growth Form: Flowering June-July, fruiting July-August; perennial forb.
Habitat: Wet meadows and boggy areas, at middle elevations.
Management needs/threats: Unknown.

7. Cryptantha fendleri (Gray) Greene (Boraginaceae)--Fendler's cryptantha
Distribution:
Region: Sandhills of the northcentral Centennial Valley; peripheral.
Montana: Known only from the Centennial Valley, Beaverhead Co.
Global: WA and OR, irregularly to Saskatchewan, sw. MT, NE, NM, and NV.
Phenology/Growth Form: Flowering May-June, fruiting June-July; annual forb.

Habitat: Sand dunes or other very sandy soils, low-mid elevations.
Management threats/needs: Populations possibly being impacted by livestock grazing.

8. Equisetum palustre L. (Equisetaceae)--Marsh horsetail
Distribution:
Region: Unknown, species reported by Dorn (1968); peripheral.
Montana: Lake and Flathead Cos., and with Dorn's report, Beaverhead Co.
Global: Circumboreal, s. in N. America to s. WA, n. ID, sw. MT, NE, and PA.
Phenology/Growth Form: Strobili produced in June-July; rhizomatous, colonial perennial.
Habitat: Streambanks, wet meadows, and marshes, from the lowlands to moderate elevations in the mountains.
Management threats/needs: Unknown; verify identification of specimens (not listed for Beaverhead Co. by Dorn (1984)).

9. Haplopappus nanus (Nutt.) Eaton (Asteraceae)--Dwarf goldenweed
Distribution:
Region: Collected once from the south side of the Centennial Valley; peripheral.
Montana: Beaverhead Co.
Global: Snake River Plains of ID, and Beaverhead Co., MT.
Phenology/Growth Form: Flowering and fruiting August-September; perennial forb.
Habitat: Barren, rocky or gravelly soil at low to mid-elevations.
Management threats/needs: Unknown.

10. Kobresia simpliciuscula (Wahl.) Mack. (Cyperaceae)--Simple kobresia
Distribution:
Region: Odell Canyon, species reported by Lowry (1979); peripheral.
Montana: Glacier and Beaverhead Cos.
Global: Circumboreal, s. to Newfoundland, Quebec, BC, and irregularly to CO, ID, MT, and OR.
Phenology/Growth Form: Flowering and fruiting June-August; perennial caespitose graminoid.
Habitat: Bogs and other wet places, montane, but generally not above timberline.
Management threats/needs: Unknown.

11. Lesquerella carinata Rollins (Brassicaceae)--Keeled bladderpod
Distribution:
Region: Nemesis Mountain area; regional endemic.
Montana: Beaverhead and Granite Cos.

Global: Lemhi and Lost River Ranges in c. ID, Teton Co., WY, and Beaverhead and Granite Cos., MT.
Phenology/Growth Form: Flowering June-July, fruiting June-August; short-lived perennial forb.
Habitat: Alpine scree slopes and talus, or among broken limestone (Rollins and Shaw, 1973).
Management threats/needs: Unknown.

12. Ligusticum filicinum Wats. (Apiaceae)--Fern-leaf lovage
Distribution:
Region: Western Centennial Mountains; peripheral.
Montana: Beaverhead and Madison Cos.
Global: ID and sw. MT, s. in mountains of w. WY to Wasatch region, UT.
Phenology/Growth Form: Flowering and fruiting July-August; taprooted perennial forb.
Habitat: Seasonally moist meadows in the mountains, middle elevations.
Management threats/needs: Unknown.

13. Leymus flavescens (Scribn. & Sm.) Pilger (Poaceae)--Sand wildrye
Distribution:
Region: Sandhills of the northcentral Centennial Valley; peripheral.
Montana: Beaverhead and Madison Cos.
Global: WA and OR to ID and sw. MT.
Phenology/Growth Form: Flowering and fruiting June-July; rhizomatous perennial graminoid.
Habitat: Sandhills and dunes to open, sandy flats.
Management threats/needs: Populations possibly being impacted by livestock grazing.

14. Oenothera pallida Lindl. var. idahoensis Munz (Onagraceae)--Pale evening-primrose
Distribution:
Region: Sandhills of the northcentral Centennial Valley; regional endemic.
Montana: Known only from the Region, Beaverhead Co.
Global: Se. ID and sw. MT.
Phenology/Growth Form: Flowering and fruiting July-August; rhizomatous perennial forb.
Habitat: Sand dunes.
Management threats/needs: Populations possibly being impacted by livestock grazing.

15. Pteryxia hendersonii (Coult. & Rose) Math. & Const. (Apiaceae)--Henderson's pteryxia
Distribution:
Region: Odell Canyon, Sheep Mountain.
Montana: Beaverhead and Carbon Cos.
Global: Sw. MT, s. to NM, w. to ID, NV, and s. UT.

Phenology/Growth Form: Fruiting in mid- and late summer; perennial forb.
Habitat: Open, often rocky places from foothills to above timberline in the mountains.
Management threats/needs: Unknown.

16. Ranunculus jovis Nels. (Ranunculaceae)--Jove's buttercup
Distribution:
Region: Centennial Mountains above Odell Creek; peripheral.
Montana: Beaverhead Co.
Global: Se. ID and sw. MT, to NV, w. WY, and adj. UT.
Phenology/Growth Form: Late March-June, flowering soon after the snow recedes; perennial forb.
Habitat: Seasonally moist forests to sagebrush slopes, mid-elevations.
Management threats/needs: Unknown.

17. Senecio debilis Nutt. (Asteraceae)--Weak butterweed
Distribution:
Region: One collection from near Upper Red Rock Lake.
Montana: Beaverhead and Madison Cos.
Global: Sw. MT and c. ID, s. through WY to CO.
Phenology/Growth Form: Flowering and fruiting June-August; perennial forb.
Habitat: Moist meadows and bottom lands, often in alkaline places.
Management threats/needs: Unknown.

18. Stephanomeria spinosa (Nutt.) Tomb (Asteraceae)--Spiny skeletonweed
Distribution:
Region: Red Rock Pass; peripheral.
Montana: Beaverhead, Madison, and Park Cos.
Global: Sw. MT and s. BC to AZ and CA.
Phenology/Growth Form: Flowering and fruiting July-August; perennial forb.
Habitat: Dry, open, commonly rocky places, low to mid-elevations.
Management threats/needs: Unknown.

19. Thelypodium sagittatum (Nutt. ex T. & G.) Endl. ex Walp. var. sagittatum (Brassicaceae)--Slender thelypody
Distribution:
Region: Lakeview area (Lesica, 1984a); peripheral.
Montana: Beaverhead and Madison Cos.
Global: Se. WA to CA, e. to sw. MT and WY.
Phenology/Growth Form: Flowering and fruiting June-July; biennial forb.
Habitat: Moist, often alkaline meadows that usually dry by midsummer, in lower mountain valleys (Hitchcock et al., 1969).
Management threats/needs: Unknown.

III. Discussion

The floristic diversity of the Centennial Region, and the existence of the above rare species within it, is dependant on the high degree of habitat diversity which exists there. The maintenance of these species within the Region will depend on compatible management schemes, and strict preservation of critical habitat where necessary. Much further study is necessary before conclusions can be reached regarding the interaction and relationships of these species with detailed environmental factors; study is needed, as well, to determine the most appropriate management strategies to be used.

Of particular interest in the region are the sandhill areas along the northcentral side of the Centennial Valley. In order to preserve the presence of the rare species which occur in this habitat, studies need to be conducted on the impacts that livestock grazing have on the area. The dynamics of sand movement in the area would also need to be studied, to determine the impacts of this factor on the rare plant populations which occur there.

Field inventories are needed, in many cases, to define the exact locations of the rare plant species in the region. During the course of such work, new populations of these would undoubtedly be found, and additional species of special concern in Montana would likely be discovered. The following taxa are some of those which may possibly be found within the Region. These are known from collections to the west of the area of concern, i.e., in the lower Centennial Valley:

Astragalus argophyllus Nutt. ex T. & G. var. argophyllus (Fabaceae)--Silver-leaf milk-vetch
Carex idahoa Bailey (Cyperaceae)--Idaho sedge
Gentiana aquatica L. (Gentianaceae)--Wet meadow gentian
Ipomopsis congesta (Hook.)Grant ssp. crebrifolia (Nutt.) Day (Polemoniaceae)--Smooth ballhead gilia
Lepidium montanum Nutt. var. montanum (Brassicaceae)--Mountain pepperweed
Primula alcalina Cholewa & Henderson (Primulaceae)--Alkaline primrose

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SOURCES OF EXPERTISE:

Dr. Robert D. Dorn
P.O. Box 1471
Cheyenne, WY 82003

Peter Lesica
Department of Botany
University of Montana
Missoula, MT 59812

Steve Shelly
Montana Natural Heritage Program
State Library
1515 E. 6th Ave.
Helena, MT 59620

Table I. List of species in different microenvironments.

AQUATIC:

Agrostis exarata
Alopecurus aequalis
Beckmannia syzigachne
Bidens cernua
Calamagrostis inexpansa
Callitriche hermaphroditica
Callitriche verna
Carex athrostachya
Catabrosa aquatica
Deschampsia elongata
Eleocharis acicularis
Eleocharis macrostachya
Elodea canadensis
Glyceria borealis
Glyceria grandis
Hippuris vulgaris
Juncus bufonius
Juncus effusus
Lemna minima
Lemna minor
Lemna trisulea
Limosella aquatica
Myriophyllum spicatum
Phalaris arundinacea
Plagiobothrys scouleri var. penicillatus
Polygonum amphibium
Potamogeton filiformis
Potamogeton friesii
Potamogeton pectinatus
Potamogeton praelongus
Potamogeton pusillus
Potamogeton richardsonii
Potamogeton zosteriformis
Ranunculus aquatilis
Rorippa gmelinii
Rorippa natans
Rorippa nasturtium-aquaticum
Sagittaria cuneata
Scirpus acutus
Sonchus uliginosus
Sparganium multipedunculatum
Stachys palustris
Utricularia vulgaris
Veronica americana
Zannichellia palustris

WETLANDS AND MARSHES AT LOWER ELEVATIONS:

Agropyron bakeri
Agrostis alba
Agrostis diegoensis
Allium brevistylum
Allium schoenoprasum
Alopecurus alpinus
Angelica arguta
Angelica pinnata
Arenaria lateriflora
Aster foliaceus var. canbyi
Aster foliaceus var. lyallii
Aster foliaceus var. parryi
Aster hesperius
Astragalus eucosmus
Barbarea orthoceras
Betula glandulosa
Calamagrostis neglecta
Cardamine breweri var. breweri
Carex aquatilis var. altior
Carex aurea
Carex douglasii
Carex festivella
Carex haydeniana
Carex hoodii
Carex interior
Carex lanuginosa
Carex limnophila
Carex nebraskensis
Carex rostrata
Carex simulata
Cerastium vulgatum
Claytonia chamissoi
Cornus stolonifera
Deschampsia caespitosa
Deschampsia elongata
Dodecatheon pauciflorum
Eleocharis palustris
Elymus canadensis
Elymus glaucus var. glaucus
Epilobium angustifolium
Epilobium glandulosum
Epilobium palustre
Erigeron lonchophyllus
Erigeron speciosus
Eriophorum angustifolium
Erysimum cheiranthoides
Festuca rubra
Galium bifolium
Galium trifidum
Geranium richardsonii

Gentiana affinis
Gentianella amarella
Geum macrophyllum var. macrophyllum
Gnaphalium palustre
Habenaria hyperborea
Habenaria unalaskensis
Heracleum lanatum
Hierochloe odorata
Iliamna rivularis
Juncus balticus var. montanus
Juncus confusus
Juncus longistylis
Ligusticum filicinum
Mentha arvensis var. glabrata
Mimulus guttatus
Mimulus lewisii
Mimulus moschatus var. moschatus
Mitella pentandra
Muhlenbergia filiformis
Muhlenbergia racemosa
Parnassia fimbriata var. fimbriata
Parnassia parviflora
Pedicularis groenlandica
Plantago tweedyi
Poa epilis
Polemonium occidentale
Polygonum lapathifolium
Populus acuminata
Populus angustifolia
Populus trichocarpa
Potentilla anserina
Prunella vulgaris
Puccinellia maritima
Ranunculus acriformis
Ranunculus cymbalaria
Ranunculus sceleratus
Rhamnus alnifolia
Ribes hudsonianum var. petiolare
Ribes inerme
Ribes setosum
Rorippa islandica
Rorippa lyrata
Rubus acaulis
Rumex maritimus
Rumex paucifolius
Sagina occidentalis
Salix bebbiana var. perrostrata
Salix candida
Salix exigua
Salix fragilis
Salix geyeriana
Salix lasiandra

Salix lutea
Salix monticola
Salix myrtillifolia
Salix planifolia
Salix wolfii
Saxifraga arguta
Scutellaria galericulata
Sisyrinchium angustifolium
Sium suave
Solidago canadensis
Spartina gracilis
Stellaria crispa
Stellaria longifolia
Stellaria simcoei
Swertia perennis
Thalictrum sparsiflorum
Thelypodium sagittatum
Triglochin maritima
Trollius laxus var. albiflorus
Typha latifolia
Veronica arvensis
Veronica serpyllifolia
Viburnum edule
Zygadenus elegans

LOWER TO MID-ELEVATION GRASSLANDS:

Agastache urticifolia var. urticifolia
Agoseris aurantiaca var. aurantiaca
Agoseris glauca var. agrestis
Agrostis scabra
Agropyron dasystachyum
Agropyron desertorum
Agropyron x pseudorepens
Agropyron repens
Agropyron trachycaulum
Agropyron smithii
Agropyron spicatum var. spicatum
Agrostis alba var. alba
Agrostis thurberiana
Alyssum desertorum
Amelanchier alnifolia
Antennaria microphylla
Antennaria rosea
Arabis hirsuta
Arabis sparsiflora var. subvillosa
Arenaria congesta
Arnica sororia
Artemisia tridentata
Aster ascendens
Aster conspicuus
Aster engelmannii
Aster falcatus
Aster occidentalis
Astragalus canadensis
Astragalus dasyglottis
Astragalus inflexus
Astragalus terminalis
Artemisia biennis
Artemisia frigida
Beckmannia syzigachne
Bromus anomalus
Bromus inermis ssp. pumpellianus var. pumpellianus
Bromus marginatus
Bromus tectorum
Calochortus nitidus
Calochortus nuttallii
Camassia quamash
Caragana arborescens
Carex filifolia
Carex pachystachya
Carex vallicola
Carex xerantica
Castilleja flava
Castilleja gracillima
Cerastium arvense
Chrysanthemum leucanthemum

Cirsium arvense var. horridum
Cirsium foliosum
Claytonia lanceolata
Clematis columbiana var. columbiana
Clematis hirsutissima
Clematis occidentalis
Collinsia parviflora
Collomia linearis
Comandra umbellatum
Corydalis aurea
Crepis acuminata
Dactylis glomerata
Danthonia intermedia
Deschampsia elongata
Dodecatheon conjugens
Draba nemorosa
Elymus cinereus
Elymus macounii
Erigeron corymbosus
Erigeron glabellus
Eriogonum heracleoides var. heracleoides
Erysimum asperum
Fritillaria pudica
Gaillardia aristata
Gayophytum humile
Gentianella prostrata
Geranium viscosissimum var. viscosissimum
Geum canadense
Glyceria striata
Hackelia floribunda
Hackelia patens var. patens
Haplopappus integrifolius
Helianthus annuus
Hesperochloa kingii
Hieracium cynoglossoides
Hydrophyllum capitatum var. capitatum
Hyoscyamus niger
Iris missouriensis
Iva xanthifolia
Juniperus horizontalis
Koeleria cristata
Lactuca biennis
Lactuca pulchella
Lappula echinata
Lepidium densiflorum
Lepidium virginicum var. pubescens
Linum perenne var. lewisii
Lithophragma bulbifera
Lomatium ambiguum
Lomatium cous
Lomatium triternatum
Lonicera involucrata var. involucrata

Matricaria matricarioides
Medicago lupulina
Medicago sativa
Melica spectabilis
Melilotus alba
Melilotus officinalis
Microseris nigrescens
Monolepis nuttalliana
Musineon divaricatum
Opuntia polyacantha
Orthocarpus luteus
Osmorhiza occidentalis
Oxytropis deflexa
Phacelia hastata var. leucophylla
Phleum pratense
Phlox hoodii
Phlox kelseyi
Phlox longifolia
Plantago major
Poa compressa
Poa pratensis
Poa secunda
Polygonum aviculare
Polygonum douglasii
Potentilla norvegica
Potentilla pensylvanica
Potentilla plattensis
Primula incana
Ranunculus glaberrimus
Rheum rhaponticum
Rosa woodsii var. ultramontana
Rubus idaeus var. gracilipes
Rudbeckia occidentalis var. occidentalis
Rumex crispus
Rumex paucifolius
Rumex salicifolius
Salicornia rubra
Sisymbrium loeselii
Solidago missouriensis
Solidago nemoralis
Stipa columbiana
Stipa williamsii
Tanacetum vulgare
Taraxacum laevigatum
Thlaspi arvense
Tragopogon dubius
Tragopogon pratensis
Trifolium longipes var. reflexum
Trifolium pratense
Trifolium repens
Trisetum spicatum
Verbascum thapsus

Zygadenus venenosus

SAGEBRUSH/GRASSLAND:

Achillea millefolium
Agropyron caninum ssp. majus var. latiglume
Antennaria microphylla
Artemisia ludoviciana
Artemisia tridentata
Artemisia tripartita
Besseya wyomingensis
Bupleurum americanum
Calamagrostis montanensis
Calochortus eurycarpus
Campanula rotundifolia
Carex douglasii
Carex multicostata
Carex xerantica
Castilleja pallescens
Cerastium beringianum
Chenopodium album
Chenopodium rubrum
Chrysothamnus viscidiflorus var. lanceolatus
Cirsium scariosum
Comandra umbellata
Crepis spp.
Delphinium glaucescens
Delphinium nelsoni
Eriogonum umbellatum
Erysimum repandum
Festuca idahoensis
Festuca scabrella
Grindelia squarrosa var. quasiperennis
Hackelia micrantha
Hordeum brachyantherum
Hordeum jubatum
Juniperus scopulorum
Koeleria cristata
Lithophragma parviflora
Lithospermum ruderale
Lupinus argenteus
Lupinus sericeus
Lomatium ambiguum
Lomatium cous
Lupinus argenteus
Lupinus leucophyllus var. leucophyllus
Lupinus sericeus
Mahonia repens
Melica spectabilis
Mertensia oblongifolia
Oenothera caespitosa var. caespitosa

Oenothera flava
Orthocarpus luteus
Oxytropis sericea var. sericea
Phlox longifolia
Poa cusickii var. cusickii
Poa juncifolia
Potentilla fruticosa
Ranunculus acriformis var. montanensis
Senecio lugens
Senecio integerrimus
Senecio pauperculus
Sisyrinchium septentrionale
Stipa comata
Stipa lettermanii
Taraxacum officinale
Tetradymia canescens
Trifolium hybridum
Zygadenus venenosus var. gramineus

SANDHILL BLOWOUTS:

Achillea millefolium
Agoseris glauca
Agropyron dasystachum
Allium textile
Antennaria dimorpha
Arabis holboellii (?)
Artemisia dracunculus
Astragalus ceramicus var. apus
Astragalus miser
Aster scopulorum
Calamagrostis montanensis
Carex douglasii
Chaenactis douglasii
Chenopodium leptophyllum
Comandra umbellata
Corispermum hyssopifolium
Cryptantha fendleri
Chrysopsis villosa
Descurainia pinnata
Elymus flavescens
Equisetum hyemale
Eriogonum cernuum
Eriogonum ovalifolium var. celsum
Eriogonum umbellatum
Erysimum repandum
Gayophytum ramosissimum
Juniperus scopulorum
Koeleria cristata
Lappula redowskii
Leptodactylon pungens

Linum perenne
Lithospermum ruderale
Lupinus argenteus
Macheranthera canescens
Monolepsis nuttalliana
Oenothera pallida var. idahoensis
Opuntia fragilis
Orobanche fasciculata
Oryzopsis hymenoides
Phacelia hastata
Phlox hoodii (?)
Phlox longifolius
Poa nevadensis
Polygonum aviculare (?)
Polygonum douglasii
Psoralea tenuifolia
Rosa woodsii
Salsola kali
Stipa comata
Tetradymia canescens
Thlaspi arvense

MIDDLE TO HIGH ELEVATION MEADOWS:

Achillea millefolium ssp. lanulosa var. alpicola
Achillea millefolium ssp. lanulosa var. lanulosa
Agoseris glauca var. dasycephala
Allium acuminatum
Allium cernuum
Androsace septentrionales
Anemone multifida var. multifida
Anemone patens
Antennaria anaphaloides
Antennaria corymbosa
Antennaria racemosa
Arabis holboellii var. retrofracta
Arabis nuttallii
Arenaria capillaris var. americana
Arenaria congesta
Arenaria lateriflora
Arnica chamissonis ssp. foliosa var. foliosa
Arnica latifolia var. latifolia
Arnica mollis
Artemisia cana
Aster campestris var. campestris
Aster foliaceus var. apricus
Aster foliaceus var. parryi
Aster integrifolius
Astragalus alpinus
Astragalus kentrophyta var. implexus
Astragalus vexilliflexus

Balsamorhiza sagittata
Bupleurum americanum
Capsella bursa-pastoris
Carex hoodii
Carex microptera
Carex phaeocephala
Carex raynoldsii
Castilleja miniata var. miniata
Castilleja sulphurea
Cirsium canovirens
Cymopterus hendersonii
Delphinium nuttallianum var. nuttallianum
Delphinium occidentale
Descurainia richardsonii var. macrosperma
Epilobium alpinum var. clavatum
Epilobium alpinum var. lactiflorum
Epilobium alpinum var. nutans
Epilobium glaberrimum var. fastigiatum
Epilobium glandulosum var. glandulosum
Epilobium paniculatum var. paniculatum
Erigeron ochroleucus var. ochroleucus
Erigeron peregrinus ssp. callianthemus var. eucallianthemus
Erigeron rydbergii
Eriogonum umbellatum var. subalpinum
Eriophyllum lanatum var. integrifolium
Erythronium grandiflorum var. grandiflorum
Festuca idahoensis var. idahoensis
Festuca ovina var. brevifolia
Frasera speciosa
Fritillaria atropurpurea
Galium boreale
Galium triflorum
Geum triflorum var. triflorum
Haplopappus acaulis
Haplopappus lanceolatus
Haplopappus suffruticosus
Haplopappus uniflorus
Hedysarum boreale
Hedysarum sulphurescens
Helianthella uniflora var. uniflora
Helianthus nuttallii var. nuttallii
Helianthus cynoglossoides
Hesperochiron pumilus
Heuchera parvifolia var. dissecta
Hordeum jubatum
Iliamna rivularis var. rivularis
Ivesia gordonii
Juncus saximontanus
Juniperus communis var. montana
Lloydia serotina
Lomatium triternatum
Lupinus argenteus var. depressus

Lupinus argenteus var. parviflorus
Lupinus sericeus var. sericeus
Madia glomerata
Mertensia ciliata
Mimulus guttatus var. guttatus
Myosotis scorpioides
Myosotis sylvatica
Nemophila breviflora
Pedicularis parryi
Penstemon attenuatus var. pseudoprocerus
Penstemon procerus var. procerus
Penstemon rydbergii var. varians
Perideridia gairdneri
Phacelia hastata var. alpina
Phacelia sericea var. ciliosa
Phleum alpinum
Poa incurva
Poa interior
Polemonium viscosum
Polygonum bistortoides
Potentilla diversifolia var. diversifolia
Potentilla diversifolia var. perdissecta
Potentilla flabellifolia
Potentilla glandulosa var. pseudorupestris
Potentilla gracilis var. brunnescens
Ranunculus eschscholtzii var. suksdorfii
Ranunculus jovis
Ranunculus inamoenus
Ribes lacustre
Ribes montigenum
Rorippa curvisiliqua var. curvisiliqua
Salix drummondiana
Salix glauca
Saxifraga arguta
Saxifraga rhomboidea
Senecio crassulus
Senecio multiradiata var. scopulorum
Senecio serra var. serra
Senecio spathulata var. nana
Senecio triangularis var. triangularis
Sibbaldia procumbens
Silene parryi
Stellaria longipes var. longipes
Stellaria obtusa
Thalictrum occidentale
Townsendia parryi
Valeriana acutiloba var. pubicarpa
Valeriana edulis var. edulis
Valeriana occidentalis
Veronica americana
Veronica wormskjoldii
Viola nuttallii var. major

Viola purpurea var. venosa
Wyethia helianthoides
Xerophyllum tenax
Zygadenus elegans

FORESTS:

Abies lasiocarpa
Acer glabrum var. glabrum
Acer negundo
Actaea rubra
Allium brevistylum
Anemone occidentalis
Antennaria corymbosa
Aquilegia flavescens
Arabis microphylla var. saximontana
Arabis nuttallii
Arctostaphylos uva-ursi
Arenaria lateriflora
Arnica cordifolia var. cordifolia
Aster eatonii
Astragalus agrestis
Astragalus miser var. hylophilus
Berberis repens
Bromus ciliatus
Bromus carinatus
Calamagrostis canadensis
Calamagrostis rubescens
Calypso bulbosa
Carex disperma
Carex geyeri
Carex microptera
Carex raynoldsii
Carex rossii
Chimaphila umbellata var. occidentalis
Cinna latifolia
Cirsium vulgare
Clematis columbiana
Clintonia uniflora
Cornus canadensis
Cymopterus hendersonii
Disporum trachycarpum
Elymus glaucus
Equisetum arvense
Equisetum laevigatum
Equisetum palustre
Erigeron philadelphicus
Erigeron speciosus var. speciosus
Erysimum asperum
Erythronium grandiflorum
Fragaria vesca var. bracteata

Fragaria virginiana var. glauca
Fritillaria atropurpurea
Galium triflorum
Gentiana affinis
Gentiana amarella
Geranium richardsonii
Goodyera oblongifolia
Glyceria elata
Habenaria hyperborea
Habenaria saccata
Hedysarum alpinum var. americanum
Helianthus nuttallii var. nuttallii
Hieracium albiflorum
Hieracium gracile
Hydrophyllum capitatum
Juniperus communis
Linnaea borealis var. longiflora
Listera borealis
Lithophragma parviflora
Lonicera utahensis
Luzula parviflora
Mitella stauropetala
Osmorhiza chilensis
Osmorhiza depauperata
Osmorhiza occidentalis
Pedicularis bracteosa var. paysoniana
Pedicularis racemosa var. alba
Penstemon cyaneus
Picea engelmannii
Pinus albicaulis
Pinus contorta var. latifolia
Pinus flexilis
Poa palustris
Poa nervosa
Poa nevadensis
Populus tremuloides
Prunus virginiana
Pseudotsuga menziesii var. glauca
Pyrola asarifolia
Pyrola secunda var. obtusata
Pyrola secunda var. secunda
Pyrola uniflora
Ranunculus jovis
Ranunculus uncinatus var. uncinatus
Ribes viscosissimum var. viscosissimum
Rubus parviflorus
Salix rigida var. watsonii
Salix scouleriana
Shepherdia canadensis
Silene parryi
Sitanion hystrix var. hystrix
Smilacina racemosa

Smilacina stellata
Sorbus scopulina var. scopulina
Spiraea betulifolia var. lucida
Stellaria obtusa
Streptopus amplexifolius var. chalazatus
Thalictrum venulosum
Urtica dioica
Vaccinium membranaceum
Vaccinium scoparium
Valeriana dioica
Viola adunca var. bellidifolia

ROCKY SLOPES AND CLIFFS:

Artemisia ludoviciana var. latiloba
Aster perelegans
Cercocarpus ledifolius var. intercedens
Chaenactis douglasii
Cymopterus hendersonii
Erigeron caespitosus
Erigeron compositus var glabratus
Eriogonum ovalifolium var. depressum
Gayophytum nuttallii
Haplopappus suffruticosus
Heuchera cylindrica var. alpina
Ivesia gordonii
Kelseya uniflora
Kobresia simpliciuscula
Lesquerella carinata
Oxyria digyna
Penstemon attenuatus
Penstemon cyaneus
Penstemon eriantherus var. redactus
Penstemon fruticosus var. fruticosus
Penstemon montanus var. montanus
Petrophytum caespitosum
Polygonum douglasii var. douglasii
Potentilla ovina
Puccinellia nuttalliana
Ribes cereum var. inebrians
Sambucus racemosa
Scrophularia lanceolata
Sedum lanceolatum var. lanceolatum
Sedum rosea
Selaginella densa
Senecio canus
Senecio streptanthifolius
Shepherdia canadensis
Solidago multiradiata var. scopulorum
Solidago spathulata var. nana
Stephanomeria tenuifolia
Symphoricarpos oreophilus var. utahensis
Townsendia montana var. montana
Viguiera multiflora var. multiflora
Vaccinium membranaceum
Vaccinium scoparium
Woodsia oregana

VEGETATION OF THE CENTENNIAL VALLEY AND MOUNTAINS

GENERAL DESCRIPTION

The Centennial study area consists of a steep topographic gradient from a mid-elevation valley at 6,600' to the continental divide at 9,900'. It is characterized by a Rocky Mountain, continental climate. Growing seasons are short, with an average of 52 frost free days per year (McEneaney, et al., 1984). A steep moisture gradient results from an east-west trending valley (10-14" annual ppt at the west end to 50" ppt at the east end near the divide). Substrates include limestone, sandstone and quartzite, till and alluvium, metamorphics, and volcanics. The moisture gradient, the diverse parent materials, and variable slope inclination and aspect (N, W, S) have resulted in a highly diverse set of microenvironments.

EXTANT VEGETATION

The extant vegetation reflects alteration by grazing, irrigation, fertilization, logging, and inhabitation. Seven general vegetation types were identified and mapped from color aerial photographs (Fig. 1), and cross-checked with other available, but sometimes conflicting vegetation maps and descriptions (McEneaney, et al., 1984; Reiswig, 1984; Johnson and Pfister, 1981; Tippy, et al., 1978; Ross and Hunter, 1976; Ross, et al., 1973; Dorn, 1969; Cotter, 1951; US Fish and Wildlife Service, undated). Vegetation boundaries were mapped to the extent of the available aerial photographs. Boundaries were drawn with changes in shrub or tree density, obvious changes in productivity, and change in species composition. Rounded versus conical crowned conifers and logging could also be detected.

Three floras were combined to represent the entire study area: Lesica (1982; sandhills and sagebrush/grassland); Lowry (1979; Centennial Mountains Instant Study area), and Dorn (1968; lower to mid-elevation valley). The compiled species have been listed by general vegetation type in Table 1. The individual authors assigned these species to slightly different and sometimes conflicting vegetation types. An attempt was made to place a species in a single vegetation type. Discrepancies were resolved by checking other authorities (Hitchcock & Cronquist (1973) for aquatic versus wetlands), although numerous errors must have occurred within the grasslands. Lastly, many species have been renamed since the period of floristic studies in the area; some species may have been named twice because of nomenclature although an attempt was made to cross reference lists. Nomenclature has not been updated to reflect Kartesz (1985). Approximately 730 species occur within the study area.

Figure 1. Extant vegetation of the Centennial Valley. Map code: 1) aquatic; 2) wetlands and marshes of lower elevation; 2a) willow thickets; 3) lower to mid-elevation grasslands; 4) middle to high elevation meadow; 5) sagebrush/grassland; 6) sandhill blowouts; 7) forests; 7a) aspen/conifer/grassland complex; 7b) woodlands; 8) rocky slopes and cliffs. Solid lines were drawn from true color aerial photographs. Dotted lines are tentative boundaries beyond the extent of the photographs (BLM, 1980).

Vegetation Types (Fig. 1; Table 1):

1. Aquatic

Aquatic vegetation includes rooted emergent, submerged, and floating species. For the Lower Red Rock and Swan Lakes, total production for 1983 was estimated to be 22,141 tons (wet weight?; Reiswig, 1984). Most of the biomass was represented by water milfoil (Myriophyllum spp.), waterweed (Elodea spp.), and muskgrass (latin name?) (Reiswig, 1984).

2. Wetlands and marshes at lower elevation:

2a. Willow thickets:

This vegetation type included wetlands (standing water), marshes, willow thickets, and riparian communities (Fig. 1). There may be taxa from mid-elevation riparian and boggy sites within the list (Table 1). Sedges (Carex spp.), bluegrass (Poa spp.), timothy (Phleum spp.), willows (Salix spp.), bog birch (Betula glandulosa), and elephantella (Pedicularis groenlandica) predominate (BLM, 1980; Tippy, et al., 1978). Some of the marshlands have been identified as saline: sedges (Carex spp.), cattails (Typha latifolia), spikerush (Juncus spp.), bulrush (Scirpus spp.), and pondweed (Potamogeton spp.) (Johnson and Pfister, 1981). Swamps including sparse spruce (Picea engelmannii) and aspen (Populus tremuloides) occur between the two lakes (moose habitat; Dorn, 1969). With further investigations, additional species might be found near warm springs (Tippy, et al., 1978). Fan-shaped patches of willow west and north of Lower Red Rock Lake appear to be the result of irrigation (BLM, 1978). The soils of the wetlands have been mapped as a complex: Typic Cryoborolls-typic Cryorthents-Argic Cryoborolls, and Cumulic Cryaquolls. Production has been estimated as 1000-1500 #/acre, 200-400 #/acre, 800-1200 #/acre, and 3000+ #/acre, respectively for each soil type (Tippy, et al., 1978).

3. Lower to mid-elevation grasslands:

The lower to mid-elevation grassland ranges from 6600' to 7040' and is 'lower' only with respect to the Centennial Study area. Many weeds were included within this category (disturbed areas; Dorn, 1968) artificially. Weeds were included in the sagebrush/grassland only when a shrub environment was specified. The classification of the band of vegetation higher in elevation than the wetlands (narrow south and wide north of the Lakes) accounts for the greatest discrepancy between vegetation maps (sagebrush: BLM, 1980; Earle, 1980; grasslands: Ross and Hunter, 1976). Care was taken to include only areas that appeared to have <25% canopy cover of sagebrush (criteria used by UNESCO; Driscoll, et al., 1984).

The lower to mid-elevation grasslands are dominated by a combination of bluebunch wheatgrass (Agropyron spicatum), idaho fescue (Festuca idahoensis), needleandthread (Stipa comata), prairie junegrass (Koeleria cristata), rabbitbrush (Chrysothamnus spp.), fringed sagewort (Artemisia frigida), and broom snakeweed (Gutierrezia sarothrae; not listed on any of the three floras, Table 1) (BLM, 1983; Tippy, et al., 1978; Cotter, 1951).

Currently 13% of the grassland is in excellent range condition (75-100% cover), 63% in good condition (50-75% cover) and 24% in fair condition (25-50% cover) (Reiswig, 1984). The soils of the lower to mid-elevation grasslands include Argic Cryoborolls, Typic Cryorthents, and Pachic Cryoborolls, and have an estimated annual production of 800-1100 #/acre, 200-400 #/acre, and 1300-1800 #/acre respectively (Tippy, et al., 1978). Peak production is during the spring to early summer. The phenological staging of common species is as follows: Festuca idahoensis = Poa secunda = Stipa comata > Agropyron spicatum > Lupinus spp. = Elymus cinereus. Annual grazing of perennials during peak growth reduces vigor and may ultimately lead to plant death. Causes of reduction to annual production includes grazing during peak growth periods, loss due to grasshoppers, erosion, and build up of litter (BLM, 1980; Reiswig, 1984).

4. Middle to high elevation meadows:

The middle to high elevation meadows refer specifically to the subalpine meadows in the southeast portion of the Centennial study area (Fig. 1), and may include high elevation boggy areas, and high elevation riparian sites above approximately 8000'. Neither the Forest Service, the Bureau of Land Management, nor the Soil Conservation Service have included descriptions of the higher elevation meadows. Many of the species between the meadow and grassland are shared (Dorn, 1968; Lowry, 1979; Table 1), although with an increase in elevation, an increase in forbs and perennial growth forms are expected. Cotter (1951) lists two complexes in southwest Montana in the 7000-8000' category: bluebunch wheatgrass-needleandthread-western wheatgrass (Agropyron spicatum-Stipa comata-Agropyron smithii), and idaho fescue-bluebunch wheatgrass-shrubby cinquefoil (Festuca idahoensis-Agropyron spicatum-Potentilla fruticosa).

The soil type corresponding to this vegetation type was a complex of forest soil and Typic Cryorthents. Production is estimated at 200-400#/acre of forage (Tippy, et al., 1978). Peak production is in early summer, later than in the lower to mid-elevation grasslands (BLM, 1980).

5. Sagebrush/grassland:

6. Sandhill blowouts:

The role of this vegetation type in the pre-white landscape is under dispute. From historical photographs of the early 1900's, little change was noted except a slight increase in sagebrush and timber at some sites (Penfold, 1979). The sagebrush/grassland type spans lower (6600') to higher (8,000') elevation. Three tipped sage (Artemisia tripartita), along with big sagebrush (Artemisia tridentata), idaho fescue (Festuca idahoensis), bluebunch wheatgrass (Agropyron spicatum), needleandthread (Stipa comata), plains reedgrass (Calamagrostis montanensis), western wheatgrass (Agropyron smithii), threadleaf sedge (Carex filifolium), and rubber rabbitbrush (Chrysothamnus nauseosus) (BLM, 1983; Tippy, et al., 1978; Cotter, 1951). Soil types are similar to the lower to mid-elevation grassland with probably slightly lower production values (Tippy, et al., 1978).

North of the lakes are two large complexes (219 acres) of sagebrush/grassland and sandhill blowouts (mapping unit 5,6; Fig. 1). Visually, oval sandy areas are surrounded by sagebrush/grassland and are easily distinguished on an aerial photograph. The east set of sandhills appear to be stablilized with a more complete cover of sagebrush. Lesica (1982) collected much of the initial data on this area (Table 1). This complex was mapped separately on the soils map as Typic Cryoborolls-Typic Cryopsamments with 700-900 #/acre and 300-500 #/acre respectively (Tippy, et al., 1978).

7. Forests:

7a. Aspen/conifer/grasslands:

7b. Woodlands

The forests occur primarily along the south side of the Centennial study area (Fig. 1) and additionally on the northeast side. The forest vegetation zone has combined all forest types from the lower elevation aspen forests (Populus tremuloidea), Douglas fir forests (Pseudotsuga menziesii; 6500-7000'), lodgepole pine (Pinus contorta; 7000-7700'), subalpine fir (Abies lasiocarpa; 7700-8800') (generalized forest series zones for southwest Montana; Arno, 1979). Forests have been defined as having > 60% canopy cover, and woodlands, 26-60% canopy cover (UNESCO defined; Driscoll, et al., 1984). Johnson and Pfister (1981) also include the limber pine series (Pinus flexilis). Differences in densities and species composition were distinguishable on aerial photos, but were unmappable due to scale and inability to identify subtypes with accuracy (i.e., Douglas fir and subalpine fir types were indistinguishable).

The soils of the forested area have been mapped as Forested Argic Cryoborolls, and Forested Typic Cryoborolls, interspersed with Typic Cryorothents. Production for forage within the forest types are 800-1100 #/acre, 1000-1500 #/acre, and 200-400 #/acre,

respectively (Tippy, et al, 1978). Projected timber production for the Centennial Primitive Area (southeast portion of study area, Fig. 1) is 112 board feet/acre/year without management, and 120 board feet/acre/year with management (BLM, 1979). This correponds closely to other estimates for average timber production for the Beaverhead National Forest (35 cubic board feet/acre/year; Pfister, et al., 1977). Current reduction in timber production results from age of the stand, wildfires, dwarf mistletoe and mountain pine beetle in lodgepole, and mountain pine beetle and spruce budworm in Douglas Fir (Costan, undated).

8. Rocky slopes and cliffs:

The mapped units of this microenvironment are just north of the Continental Divide, in the southeast portion of the Centennial study area (Fig. 1). Additional sites occur at lower elevation but were too small to be mapped. No descriptions are available for this type from the Forest Service or Bureau of Land Management. The Soil Conservation Service has a similar mapping unit defined as 70% rockland, 30% vegetation (mapping unit #62; Ross and Hunter, 1976). Production is estimated to be 50 gr/m2, similar to IBP alpine sites).

POTENTIAL VEGETATION

Climax vegetation was predicted from geographic province, soil type and annual precipitation, and was mapped by the Soil Conservation Service for the state of Montana (Poss and Hunter, 1976). The Centennial Valley portion of the map was enlarged, and boundaries of the range sites were transferred to the base map (Figure 2). There is a discrepancy between the mapping scales, so that boundaries are not precise.

The Centennial Valley lies within the Northern Rocky Mountain geographic province. Five types of range site associations were identified by Ross & Hunter (1976):

1) Subirrigated and wetland (SCS mapping unit #47);
2) Silty range site, 10-14" ppt SCS mapping unit #37);
3) Silty range site, 15-19" ppt (SCS mapping unit #38);
4) Silty range site, 20-24" ppt (SCS mapping unit #39);
5) Subalpine fir and Douglas fir climax forests, 20-45" ppt (SCS mapping unit #53).

For each range site, Ross and Hunter (1976) listed species expected to be a component of the climax vegettion. These lists were compared with the compiled list of extant vegetation (Table 1; Lesica, 1982; Lowry, 1979; Dorn, 1968).

On the valley bottom, the subirrigated and wetland range site association (mapping unit #1, Fig. 1) is geographically comparable to the wetlands and marshes of the extant vegetation (mapping unit #2, Fig. 1). The following is a list of species

Figure 2. Potential vegetation of the Centennial Valley. Map code for range site associations within the Foothills and Mountains geographical province: 1) subirrigated and wetland; 2) silty range site, 10-14" ppt; 3) silty range site, 15-19" ppt; 4) silty range site, 20-24" ppt; 5) subalpine fir and Douglas-fir climax forests, 20-45" ppt. Boundaries were enlarged and transferred from Ross and Hunter (1976).

expected in the climax vegetation. Species which are not a component of the extant vegetation are contained within brackets.

> Calamagrostis spp., Deschampsia caespitosa, [Glyceria grandis], Carex spp., [Agropyron trachycaulum], [Elymus cinereus], Salix spp., [Potentilla fruticosa], Spartina gracilis, Pedicularis groenlandica, Mimulus spp., [Trifolium spp.], [Castilleja spp.], Sisyrinchium angustifolium. (Ross and Hunter, 1976).

No habitat or community types have been formally defined for this range site. Wetlands are considered to be 'subclimax' by the BLM (1980) and successional to a more well drained type. On a biological time scale, the valley bottom will probably never be well drained and thus represents maximum development under saturated soil conditions.

At the mouth of the valley, the foothill province, silty range site, 15-19" (mapping unit #2, Fig. 2) is geographically comparable to the lower to mid-elevation grasslands and sagebrush/grassland of the extant vegetation (mapping units #3 and 5, respectively; fig.1.). The following is a list of species expected in the climax vegetation (same format as above):

> Agropyron spicatum, [Festuca scabrella], [Stipa comata], Koeleria cristata, Agropyron smithii, Agropyron dasystachyum, [Stipa viridula], Elymus cinereus, Carex filifolia, Fabaceae, Artemisia tridentata, [Eurotia lanata] Festuca idahoensis. (Ross and Hunter, 1976).

Based on data from SCS near-pristine sites, the following community types (c.t.) and habitat types (h.t.) have been associated with this range site in other parts of Montana: Agropyron spicatum/Stipa comata (c.t.), Agropyron spicatum/Koeleria cristata (c.t.), Agropyron spicatum/Stipa viridula (c.t.), Agropyron spicatum/Agropyron smithii (h.t.). Community types were named from the dominant/subdominant species. With further study and work on plant community classification, additional community types are expected. For the AGSP/AGSM h.t., the presence of Agropyron spicatum, Agropyron smithii, and Carex stenophylla, and the absence of Festuca idahoensis, Festuca scabrella, and Bouteloua gracilis are indicative of the habitat type. No indicator species have been formally defined for the community types within this range site. The BLM (1980) suggests that a combination of Festuca idahoensis and Agropyron spicatum should dominate the site (FEID/AGSP; Mueggler and Stewart, 1980). Johnson and Pfister (1981) list the FEID Series as climax which would be within this vegetation zone. The BLM (1980) has proposed Agropyron spicatum, Festuca idahoensis, and Artemisia tridentata to be key species indicative of range site vigor.

On the north side of the valley, the foothill province, silty range site, 15-19" (mapping unit #3, Fig. 2) is also geographically comparable to the lower to mid-elevation grasslands and sagebrush/grassland, with a little of the flora representative for the middle to high elevation meadows of the extant vegetation (mapping units #3, 5 and 4 respectively; Fig. 1). The following is a list of species expected in the climax vegetation (same format as above):

> Festuca scabrella, Festuca idahoensis, Agropyron spicatum, Stipa columbiana, Elymus cinereus, Hesperochloe kingii, [Danthonia parryi], Agropyron trachycaulum, Lupinus spp., Geranium viscosissimum, Balsamorhiza sagittata, Geum triflorum, Artemisia tridentata, Delphinium occidentale, Koeleria cristata, Danthonia intermedia, [Andropogon gerardii]. (Ross and Hunter, 1976).

Based on data from SCS near pristine sites (Ross, et al., 1973), the following community types (c.t.) and habitat types (h.t., defined by Mueggler and Stewart, 1980) have been associated with this range site in other parts of Montana: Festuca idahoensis/Agropyron spicatum (h.t.; FEID/AGSP), Festuca idahoensis/Festuca scabrella (c.t.), Festuca scabrella/Agropyron spicatum (h.t.; FESC/AGSP), Festuca scabrella/Stipa viridula (c.t.), Agropyron spicatum/Poa cusickii (c.t.). Other plant communities known to occur on the north side of the valley within the sand dunes include Festuca idahoensis/Stipa comata (c.t.), and Agropyron dasystachyum/Phacelia hastata (Lesica, 1982). With further field and classification studies, many additional community types and habitat types are expected. Indicator species have been indentified only for the habitat types (Mueggler and Stewart, 1980). For FEID/AGSP h.t., the presence of both Festuca idahoensis and Agropyron spicatum, and the absence or rarity of Bromus spp., are indicative of the habitat type. For FESC/FEID h.t., the presence of Festuca scabrella, and Geranium viscosissimum and/or Danthonia intermedia are indicative of the habitat type. For FESC/AGSP h.t., the presence of Festuca scabrella, Agropyron spicatum, and lack of woody shrubs are indicative of the habitat type.

At the far eastern end of the valley, the foothill province, silty range site, 20-24" ppt (mapping unit #4, Fig. 2) is geographically comparable to patches of middle to high elevation meadows combined with some of the flora of the lower to mid-elevation grassland (mapping unit #4 and 3, respectively; Fig. 1). The following is a list of species expected in the climax vegetation (same format as above):

> [Festuca scabrella], Stipa columbiana, [Stipa richardsonii], Bromus marginatus, [Agropyron subsecundum], Agropyron trachycaulum, Elymus cinereus, Festuca idahoensis, Lupinus spp., Geranium viscosissimum, Geum triflorum, Delphinium

occidentale, Artemisia tridentata, Hesperochloe kingii, Trisetum spicatum, Melica spectabilis, Bromus anomalus, Populus tremuloides, Polygonum bistortoides. (Ross and Hunter, 1976).

Based on data from SCS near pristine sites (Ross, et al., 1973), the following community type (c.t.) and habitat type (h.t., defined by Mueggler and Stewart, 1980) have been associated with this range site in other parts of Montana: Festuca scabrella/Festuca idahoensis (h.t.; FESC/FEID), and Festuca scabrella/Stipa richardsonii (c.t.). With additional work on classification and field studies, more community and habitat types would be listed. Indicator species for the FESC/FEID h.t. include Festuca scabrella, and Geranium viscosissimum and/or Danthonia intermedia. This is within the same general grassland type, FEID/AGSP, as predicted by the BLM (1980) for moist, higher elevation grasslands.

On the south side of the valley are subalpine fir and Douglas-fir climax forests on moderately to very steep mountain slopes, 20-45" ppt (mapping unit #5, Fig.2). The climax forest types correspond to forest, aspen/conifer/grassland complex, and woodlands of the extant vegetation (mapping units 7, 7a, 7b respectively, Fig. 1). The typical overstory composition includes Abies lasiocarpa (65%), Pseudotsuga menziesii (25%), and Picea engelmannii (10%) (Ross and Hunter, 1976). These correspond to the series level of classified forest types of Pfister, et al. (1977). Johnson and Pfister (1981) also list the Pinus flexilis Series within the Red Rocks Wildlife Refuge. Dorn (21969) describes a subalpine fir forest type (Abies lasiocarpa/Calamagrostis rubescens h.t.; Pfister, et al., 1977), a Douglas fir forest type (Pseudotsuga menziesii/ Calamagrostis rubescens h.t.; Pfister, et al., 1977), a spruce woodland very similar to Picea/Equisetum arvense h.t. (Pfister, et al., 1977), and an aspen/conifer forest (Populus tremuloides -conifers h.t.; Habeck, 1970; Cooper and Pfister, 1980). Information on the forest indicator species for each habitat type can be found in Lee, et al. (1978), and Pfister, et al., (1977). Pfister, et al. (1977) lists 45 habitat types under the Abies lasiocarpa, Picea, Pinus flexilis, and Pseudotsuga menziesii Series, of which perhaps 15 are represented in the Centennial Mountains. A formal habitat typing within the Centennial area is needed.

SUCCESSION

In general, little is known about grassland successional sequences. However, of the few studies that have been done, one was completed in southwest Montana with one site within the Centennial Study Area (Cotter, 1951). Cotter (1951) suggests two generalized successional sequences for 1) disturbed sites which result in grasslands (Fig. 3a); and 2) disturbed sites which result in shrublands (Fig. 3b). He has also worked out a successional sequence for the sandhill area (Staudenmeyer Ranch; Fig. 3c). Sequences were developed from repeat aerial photography (10 yrs apart), and population dynamics studies of shrubs.

The actual duration of successional stages may be dependent on annual precipitation during those years and land use. Fertilization may speed vegetative cover, but it may also promote weedy species (BLM, 1980). Irrigation has also resulted in obvious succession within the Centennial Valley from low elevation grasslands to willow thickets (Tippy, et al., 1978).

Repeat photographs are available for a number of sites in the Centennial area starting in the early 1900's (Penfold, 1979). The landscape showed little change except an increase in Douglas fir and aspen, and a little increase in sagebrush. However, soils descriptions from the Douglas fir zone are Mollisols (Typic Cryoborolls), a deep, rich soil tyically developed under grasslands (Tippy, et al., 1978; BLM, undated). It is well known that suppression and exclusion of fire will allow Douglas fir and sagebrush to invade and establish within grasslands (Arno and Gruell, 1985; Costan, undated).

A number of western Montana forest successional sequences have been worked out (Arno, et al, 1985), but only two describe successional sequences for the drier forest habitat types common in the Centennial Valley (Arno and Gruell, 1985; Lyon and Stickney, 1976). Just west of Boulder, Montana (considerably north of the Centennial study area), Douglas fir stands have skeletons of sagebrush or dying aspen in the understory indicating a successional sequence. This has been diagrammed for Douglas fir in Fig 4a (Arno and Gruell, 1985). Generalized successional sequences after fire have been described for the drier forest types (BLM, undated). For lower elevation forests after fir, aspen invades, then results in a Douglas fir climax forest. For higher elevation forests after fire, lodgepole pine invades, followed by spruce, followed by a fir-spruce climax forest (BLM, undated. Data suggest that lodgepole pine forests may be climax within the region (Despain, 1983).

Although the studies were not done in Montana, a successional sequence has been worked out for relatively dry subalpine forests in the Colorado Front Range (Fig. 4b; Day,

1963; Stahelin, 1943). Lodgepole pine invades quickly, followed by an irregularly aged spruce forest with subalpine fir in the understory. Engelmann spruce maintains dominance in the canopy for over 250 years, but is eventually replaced by subalpine fir approximately 350 years after fire. This sequence may be more similar than those presented for northwest Montana subalpine fir forest types.

Figure 3. Generalized plant successional sequences on Southwest Montana benchlands for a) disturbed sites (pocket gophers) which result in shrublands; and c) sandhill blowouts (Staudenmeyer Ranch, Centennial Valley). All sequences transcribed from Cotter (1951, pg. 59, 60, 61). Species in parentheses are optional dominant species in the sequence. Vertical arrows indicate increase or decrease through time.

a) disturbed sites which result in grasslands:

patches of bare soil	-----> *Salsola kali*	-----> *Eurotia lanata* *Salsola kali*	-----> *Eurotia lanata*	-----> *Stipa comata* *Eurotia lanata*	-----> *Stipa comata* + other species solid grass cover
(recent, inactive)	2 yr	3 yr	4 yr	5 yr	15 yr +

b) disturbed sites which result in shrublands:

patches of bare soil	-----> *Salsola kali*	-----> *Eurotia lanata* *Salsola kali*	-----> *Stipa comata* *Agropyron spicatum* *Eurotia lanata*	-------> *Artemisia tridentata* *Agropyron smithii* *Stipa comata* *Agropyron spicatum* *Eurotia lanata*	
(recent, inactive)	2 yr	3 yr	4 yr	5 yr	

-----> *Artemisia tridentata* *Agropyron smithii* *Stipa comata* *Eurotia lanata*	-----> *Artemisia tridentata* *Agropyron smithii* *Stipa comata* *Eurotia lanata*	-------> *Artemisia tridentata* *Agropyron spicatum* *Gutierrezia longifolia* *Chrysothamnus viscidiflora* *Eurotia lanata*	-----> *Artemisia tridentata* *Agropyron spicatum* *Gutierrezia longifolia*
6-15 yr	15-20 yr	20-30 yr	30-40 yr

-----> *Artemisia tridentata*
Agropyron spicatum

40 yr ++

c) sandhill blowouts (Staudenmeyer Ranch, Centennial Valley):

bare soil ----->	*Salsola kali* (*Cryptantha* spp.)	--------> *Eurotia lanata* (*Chrysothamnus viscidiflorus*) (*Aristida* spp.)	-----> *Stipa comata*

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Nancy Grulke, Plant Ecologist
Montana Natural Heritage Program
1515 E. 6th Street
Helena, MT 59620

ECONOMIC AND RECREATIONALLY IMPORTANT SPECIES

Assigning economic value to wildlife is difficult at best and in most cases never considered. Monetary value can be placed on harvested furbearers as the market dictates. Sport fish and game species may be valued by the licenses fees paid to pursue them. Hunting and fishing in Montana generates millions of dollars annually for the tourist industry and many communities derive a significant portion of their livelihood from these activities. These economic analyses are routinely performed. The economic value of non-consumptive use of wildlife has only recently been considered and attempts at placing monetary value on it can only be rough estimates.

There are certain species which are highly visible, glamorous, and sought out by the public. Assemblages of species may make particular areas unique and highly desirable for visitation. In the former, these individual species may rate high in economic and recreational value. The later may rank lower but are still considered an important part of the aesthetic value of the area. Providing public access may be a simple matter of distributing trail guides and check lists. For the consumptive use of wildlife, it may involve intensive management for both people and the fish and wildlife they pursue. This is generally the case with consumptive sport hunting, fishing and trapping. Typically, species receiving the most study and management are game species or threatened and endangered species. Our limited knowledge of the nongame species in the Centennial Valley is a result of this and the fact that the area is relatively remote and inhospitable during much of the year.

Carnivorous mammals, fish and birds of the Centennial Valley are listed with comments on their status, distribution and economic or recreational values. Critical habitats for the life cycle completion of fauna in the Centennial Valley are given in Table 2.

CARNIVORES:

Mountain Lion (Felis concolor) - uncommon with periodic sightings in the Centennial Valley. No information on population trends. Listed as game species in Montana.

Lynx (Felis lynx) - rare, historic and present status in the Centennial Valley unknown. Generally confined to dense forests at higher elevations. This is a valuable furbearer but of limited economic impact in the Centennial Valley.

Bobcat (Felis rufus) - locally common, historic and present status in the Centennial Valley unknown. Occupies wide range of habitat, usually lower elevations in rocky

sagebrush and forests.This species is a valuable furbearer.

Grizzly Bear (Ursus arctos) - rare, historically present but eliminated from the Centennial Valley soon after settlement. Several bears have been frequenting the area in recent years and one bear was trapped and released North of the Centennial Valley in 1984. (See Appendix A in Rare Species section). Yellowstone grizzly bear population is protected by Federal and State laws - listed as threatened by USF&WS.

Black Bear (Ursus americanus) - uncommon, status unknown. Will occupy wide range of habitat but generally restricted to coniferous forests. Listed as game species in Montana.

Raccoon (Procyon lotor) - uncommon, reported from locality near Monida, fewer than 10 sightings in past decade in upper Centennial Valley. This species may continue to expand its range and numbers in the Centennial Valley. Normally associated with riparian/forest habitat. Nongame species with commercial value.

Red Fox (Vulpes vulpes) - common, historical status in Centennial Valley poorly documented. This species has increased its range and numbers throughout Southwestern Montana. Population in Centennial Valley has increased in past 15 years. Nongame wildlife with commercial value.

Gray Wolf (Canis lupus) - extirpated, last observed during the 1940's and 1950's. Most sightings were from the east end of the valley. The Centennial Valley shows excellent potential for wolf recovery. However, full recovery will likely yield to conflicts with established livestock ranching interests.

Coyote (Canis latrans) - common, historically uncommon in the Centennial Valley. Populations have increased in recent years and fluctuate with prey density. Occupies virtually all habitats present. Predatory animal with commercial value.

River Otter (Lutra canadensis) - uncommon, historically found throughout the Centennial Valley. Heavy trapping greatly reduced this species' numbers which are slowly recovering.Otters are closely associated with riverine and lacustrine habitat. A family group resides at Elk Lake and periodic observations are made on the refuge. Valuable furbearer with restricted take.

Striped Skunk (Mephitis mephitis) - common, found throughout the Centennial Valley but most abundant in wetland marshes and riparian habitat. The USF&WS plans for limited control

on skunks to enhance waterfowl production. This is a predatory animal with limited commercial value.

Spotted Skunk (Spilogale gracilis) - common, less common than the striped skunk but also found throughout much of the valley. Both species of skunks have increased in population over the past two decades. Predatory animal of little commercial value.

Badger (Taxidea taxus) - common, found in sagebrush/grassland and well drained meadows. Information on historic occurrence and status is poorly known. Nongame species with commercial value.

Wolverine (Gulo gulo) - rare, one individual trapped in past 10 years. Status poorly documented in Centennial Valley. Valuable furbearer with restricted harvest limit.

Mink (Mustela vison) - common, primarily found in wetland/ riparian areas. No information available on historic abundance or distribution. Currently widespread and numerous in appropriate habitat. Valuable furbearer.

Short-tailed Weasel (Mustela erminea) - common, found in most habitats, primarily woodland. Historic and current status in Centennial Valley poorly known. Predatory animal of limited commercial value.

Long-tailed Weasel (Mustela frenata) - common, found in wide range of habitats. Like the short-tailed weasel this species is poorly known in the Centennial Valley. Predatory animal of limited commercial value.

FISH:

Mountain whitefish (Prosopium williamsoni) - recent surveys indicate this species is uncommon in streams and absent in lakes and ponds. It is a resident of the larger streams throughout its life cycle. No historical information was available on population levels or distribution of this species in the Centennial Valley, although Nelson (1953) considered it common in Red Rock Creek. It was not detected in creek surveys by MTDFW&P and therefore may be regarded as a minor component of the sport fishery. Elsewhere this species is a sport fish with liberal creel limits.

Yellowstone cutthroat trout (Salmo clarki lewisi) - recent surveys have determined that this fish is uncommon in much of the Centennial Valley and absent in the lower valley streams. Spawning was detected only in Red Rock Creek and Hell Roaring creek. Hybrid Rainbow x cutthroat trout

crosses were detected in low density in O'Dell Creek.Nelson (1953) lists the cutthroat as common in the headwaters of the larger streams but rarely observed in the valley streams. Cutthroat trout infrequently appear in creel surveys, supporting the conclusion of their low abundance. This fish is a highly prized sport fish with a restricted creel limit.

Brook trout (Salvelinus fontinalus) - common and locally abundant in virtually all streams. Census data identify it as abundant to absent in lakes and ponds. This is an introduced species which may have impacted the native cutthroat population. It is a desirable game fish and often is the most numerous species in creel surveys.

Lake trout (Salvelinus hamaycush) - found only in Elk Lake. Census data suggest they are common. They represent 25% of the fish caught but are small on average. This is a highly prized sport fish.

Arctic grayling (Thymallus arcticus) - locally common, in the Centennial Valley. This species has been reduced in numbers and distribution throughout its range in Montana. Early reports from the 1930s to 40s suggested they were abundant. Severe stream habitat deterioration from cattle grazing was recognized as early as 1940s.

Grazing has been reduced on Refuge land but still is detrimental to spawning habitat on private land east of the refuge. Census data indicate that most Grayling reside in upper Red Rock lake and move out to spawn in lower Red Rock Creek. This is an important game fish species in southwestern Montana.

Rainbow trout (Salmo gairdneri) - Attempts to introduce this species were largely unsuccessful. Lund (1974) found a preponderance of rainbow x cutthroat trout hybrids in Elk Lake tributaries. Rainbows occur primarily in McDonald Pond and Elk Springs Creek. Other streams have rainbow and/or hybrid trout in low densities. This is a highly prized game species.

Other fish species in the upper Centennial Valley are:

Longnose sucker (Catostomus catostomus - locally abundant in lakes and streams;

White sucker (Catostomus commersoni) - locally common;

Burbot (Lota lota) - uncommon;

Mottled sculpin (Cottus bairdi) - common in upper streams.

BIRDS:

Approximately 255 species of birds have been recorded in the Centennial Valley. Many of these species are fall migrants or irregular/accidental occurrences. However, the refuge and surrounding area has records of over 150 breeding species (Skaar, et al., 1985; US Fish and Wildlife Service, 1985). Population trends for virtually all species is unknown. Habitat associations of species are given in Table 2.

On top of the list of economic and recreational species are waterfowl; 28 of the 43 species recorded are known to nest here. Most are game species and attract duck hunters during the fall season. Others, such as the Trumpeter Swan, are of esthetic importance and attract visitors to see them. The Centennial Valley hosts an incredible diversity of raptors. Virtually every species of northern North American raptor can be seen here. Twelve of the 15 species nest here including the only known wild peregrine falcon nest in Montana.

Over 20 species of shorebirds, including herons, cranes and gulls, nest in the wetland marshes or upland meadows. The Centennial Valley is a significant nesting area for the sandhill crane and long-billed curlew in Montana. Five species of owls breed here, including the great gray owl. This assemblage of owls occupies every type of habitat available, from open grasslands and marsh to dense mature forest. Five species of woodpeckers also nest in the area. These species tend to be more restricted to the forested areas.

The most abundant and diverse group is the passerines or song birds. There are over 75 species breeding in the Centennial Valley. They occur in all available habitats and in varying degrees of abundance. For a listing of habitat association for bird taxa see Table 2. Information on seasonality and breeding of individual species can be found in the bird checklist of the Red Rock Lake National Wildlife Refuge (US Fish and Wildlife Service, 1985).

TABLE 2

HABITATS CRITICAL TO LIFE CYCLE COMPLETION OF FAUNA:

SPECIES	WETLANDS/ MARSH	LOW TO MID ELEVATION GRASSLAND	SAGEBRUSH/ GRASSLAND	FOREST
WATERFOWL				
-breeding (29 spp.)	X			
-nonbreeding (3 spp.)	X			
CHARADRIIFORMES*				
-breeding (14 spp.)	X	X		
-nonbreeding (13 spp.)	X			
CRANES / HERONS				
-breeding (4 spp.)	X	X		
-nonbreeding (1spp.)	X	X		
FALCONIFORMES				
-breeding (12 spp.)	X	X	X	X
-nonbreeding (3 spp.)		X		X
GALLIFORMES				
-breeding (3 spp.)		X	X	X
STRIGIFORMES				
-breeding (5 spp.)	X	X		X
-nonbreeding (2 spp.)		X		X
APODIFORMES				
-breeding (3 spp.)		X	X	X
nonbreeding (2 spp.)		X	X	
CORACIIFORMES				
-breeding (1 spp.)	X			
PICIFORMES				
-breeding (5 spp.)				X
-nonbreeding (3 spp.)				X
PASSERIFORMES				
-breeding (76 spp.)	X	X	X	X
-nonbreeding (19 spp.)	X	X	X	X
MAMMALS				
INSECTIVORES (4 spp.)	X	X		X
CHIROPTERA (7 spp.)	X		X	X

*Includes: Gaviiformes, Podicepiformes, Pelicaniformes, Ciconiiformes, Anseriformes.

HABITATS CRITICAL TO LIFE CYCLE COMPLETION OF FAUNA (cont.):

SPECIES	WETLANDS/ MARSH	LOW TO MID ELEVATION GRASSLAND	SAGEBRUSH/ GRASSLAND	FOREST
LAGOMORPHS (6 spp.)		X	X	X
RODENTS				
-Sciuridae (9 spp.)		X		X
-Geomyidae (1 spp.)		X		
-Heteromyidae (1 spp.)		X	X	
-Castoridae (1 spp.)	X			X
-Cricetidae (7 spp.)	X	X	X	X
-Zapodidae (1 spp.)		X		X
CARNIVORES				
-Canidae (2 spp.)	X	X	X	X
-Ursidae (1 spp.)				X
-Procyonidae (1 spp.)	X			X
-Mustidae (6 spp.)	X	X	X	X
-Felidae (2 spp.)				X
UNGULATES				
-Cervidae (4 spp.)		X	X	X
-Bovidae (2 spp.)		X		X
AMPHIBIANS				
-Anurans (2 spp.)	X			
REPTILES				
-Squamata (1 spp.)	X	X	X	X

INDICATOR SPECIES

The identification of species as indicators of the environment is more widely used in floristic classification. It is possible to describe animal distributions and associations with this approach, although many animal species have distributions that are wider than the floristic classifications. Here we identify those species that provide stability to a system or are an integral part that are identified with it. These species are often unique or specialized in their distribution, feeding, breeding, locomotion or some other aspect of their biology. Taxa are identified here as indicators of the environmental quality in the Centennial Valley.

The trumpeter swan (Cygnus buccinator) is perhaps the most highly visible species in the valley. Recent declines in the population and productivity of the swans brought about great concern. This has initiated studies which provided important data on the aquatic system. Aside from the conclusion that the swans had exceeded their carrying capacity on the refuge (Page 1976), there was also evidence that they were in poor nutritional condition after the long winter (Shea 1979).

The aquatic vegetation which the swans depend on has changed dramatically. In 1955-56 Beed (1957) estimated the bottom of Upper Red Rock Lake to be 88% vegetated and commented that "...the very fertile bottom supports an almost unbelievably abundant and luxuriant plant growth." By 1975 (Roscoe 1976) found only 44% of the Upper Red Rock Lake bottom was vegetated. It exhibited the most sparsely vegetated bottom of any of the lakes surveyed. One plant, waterweed (Elodea canadensis) is the preferred food of swans and many duck species. In the past 60 years waterweed has dwindled from "thick stands" to its present state of practically nonexisting (Roscoe 1976).

These events have been attributed to siltation of the lake caused by excess cattle grazing in the watershed. Overgrazing of aquatic vegetation by the swans is also mentioned. It may be argued that swans are artificially maintained at high levels by winter feeding. An important factor to consider is the rate at which the lake has been filling in. In 1897, the Upper Red Rock Lake was recorded at up to 25 feet deep by J.V. Bower. Currently there are few places deeper than six feet deep (MTDFW&P surveys). This accelerated sedimentation poses the greatest threat to the continued existence of the swans on the refuge.

Nesting swans use four primary nesting areas in the Centennial Valley. In the past four years Swan Lake has had 5-8 nests, Upper Red Rock Lake has had 3-4 nests, River Marsh has had 0-10 nests, Lower Red Rock Lake has had 1-4 nests, and the Red Rock River above Lima Reservoir has had 18 pairs nesting. All but the last represent declines from the 1970s (R. Gale and

B. Reisweig, pers. comm.).

Swans nesting in the lakes and marshes rely on heavily vegetated shorelines and usually build their nests on top of muskrat houses. River nesting swans seek the seclusion of oxbows and back waters. These birds are closely monitored and refuge management is focused on the protection, study, and propagation of swans, including winter feeding.

The bald eagle (Haliaeetus leucocephalus) is represented by two nesting pairs in the east end of the valley. One nest is an old established pair. They have fledged 2 young on most years since counting began in 1978. The other nest was identified in 1983 and fledged 2 young in 1983 and none in 1984. Data from 1985 were inconclusive (R. Escano, pers. comm.).

The presence of successfully breeding bald eagles in the Centennial Valley is an indicator of the relative seclusion and the abundance of fish and waterfowl as prey being available. These birds leave the valley for the winter. The valley may experience further growth in the number of breeding resident pairs but the territorial nature of this species will likely be a limiting factor. Occasionally non-resident birds are sighted in the valley.

Bald eagles are heavily dependent on the aquatic system for their food source. No food studies have been conducted in the Centennial Valley but presumably the eagles take fish and vulnerable waterfowl. Eagles feeding on hunter-crippled or lead-poisoned waterfowl have suffered lead poisoning. Although no eagle poisonings have been documented in the Centennial Valley, the USF&WS has plans to ban lead shot for waterfowl hunting on the refuge starting in 1986 (B. Reisweig, pers. comm.).

Although active management for bald eagles in the Centennial Valley is minimal, their reproductive success is monitored closely by the interagency eagle working group (USF&WS, BLM, USFS, MTDFW&P). Observers fly over the nests to count fledglings and look for new nests in the area.

The peregrine falcon (Falco peregrinus) nests in the cliffs of the Centennial Mountains over-looking the refuge. Hacking of captive-reared falcons in the area has resulted in the establishment of Montana's only known wild nesting pair. These birds rely on the refuge for hunting, particularly the wetland's abundant waterfowl.

Nest success since 1984 has been good with 2 or 3 young fledged per year. Coordinated efforts by the BLM, USF&WS, USFS, MTDFW&P and the Peregrine Fund have successfully released 46 captive-reared fledglings in the valley since 1981. Pending

budget cuts may reduce this effort in the next few years but plans are to "saturate" the tri-state area with peregrine falcons (B. Reisweig, pers. comm.).

The peregrines in the Centennial valley are closely monitored and the management plan calls for their full recovery in the tri-state area. The outlook for additional pairs nesting in the area is good. These birds leave for the winter and return by late April. Observers closely monitor the cliffs in the area for sign of returning birds.

The reproductive success of the peregrine falcon may be used as an indicator of certain aspects of environmental quality. These birds are extremely sensitive to pollutants, particularly chlorinated hydrocarbons (Enderson and Berger 1970). Unfortunately these compounds are long-lived and may be ingested on the falcon's winter range and affect reproductive output in subsequent years (Enderson et al. 1982).

The Centennial Valley is one of a few locations where native arctic grayling (Thymallus arcticus) still exist in Montana. This species is sensitive to water quality degradation (Nelson 1953) and competition from exotic species (Vincent 1962). While the grayling may not play a significant role in the diet of piscivorous birds or mammals, it is an indicator of overall habitat quality, particularly spawning streams. Grayling are highly impacted by poor substrate conditions and low waterflows in spawning streams (Lund 1974). The grayling could therefore be used as one of several possible indicators of watershed quality in the upper Centennial Valley.

The Red Rock Lakes National Wildlife Refuge has adopted more active management plans for the grayling (B. Reisweig, pers. comm.). Studies initiated in 1985 involve telemetry studies of grayling to learn more of their movements. Removal of eggs, hatching and returning fry to the streams will enhance wild reproduction. Also, plans are underway to develop another isolated population outside of the Centennial Valley. The Blackfeet Reservation is being considered as a planting site for Centennial grayling.

O'Dell Creek, formerly a significant spawning stream, is being considered for rehabilitation. Acquisition of the stream south of the refuge is being negotiated. The protection of O'Dell Creek may reverse the declining trend of the grayling population in Lower Red Rock Lake.

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Fisheries Management

Fisheries management in the Centennial Valley has historically been and currently remains the responsibility of the Montana Department of Fish, Wildlife and Parks Fisheries Division. Interagency cooperation on projects in the drainage involves the USF&WS, BLM, USFS and DFW&P (see Peterson et.al 1978). Sport fishing for all species is allowed on the refuge under state regulations with minor adjustments to reduce conflict with refuge operation.

The Fishery in the Centennial Valley provides an important economic resource for the area. Sport fishing on the refuge is of high quality in most areas, with large trout (4-6 pounds) and grayling (16-18 inches) caught on occasion (Peterson et.al. 1978). Fishing pressure is moderate, estimated at between 3,000 and 4,000 fishing days per year in 1975 (a fishing day is one four-hour visit). This generates between $19,000 and $25,500 for the local economy, based on a national average of $6.30 spent per fishing day.

The fishery of the Centennial Valley plays an integral role in the biological stability of the aquatic system and surrounding area. The valley formerly abounded with grayling and cutthroat trout. Introductions of exotic rainbow and brook trout may have "improved" the sport fishery but they have added to the many factors which jeopardize the existence of the native species. Native lake trout were known to occur in Elk Lake, one of only two sites in the upper Missouri River drainage. This unique population is no longer pure due to plantings of eastern strains of lake trout. Yellowstone cutthroat trout readily hybridize with introduced rainbow trout, continuing the genetic erosion of this local endemic form. Grayling are under increased pressure from competing exotics in the watershed. But perhaps the most acute of the threats on this once unique and spectacular fishery in the severe degradation of water quality and spawning habitat. Excess siltation and pollution of streams will directly effect grayling and trout by eliminating spawning habitat, suffocating eggs and fry.

Indirect effects of habitat degradation include reduction and elimination of aquatic invertebrates - an important food source, provide disturbed conditions which allow other rough fish species a competitive edge, and accelerated eutrophication and filling in of lakes. It is for these reasons that fishery management in the Centennial should be given a higher priority.

Fishery management objectives as identified by the MT. DFW&P and USF&WS include: a) maintain quality fishing as a recreational output; b) provide and maintain habitat for water dependent and fish-eating wildlife, as an integral part of the objective for maximizing native wildlife forms; c) assure

the security and increase the numbers of the arctic grayling. The management of the MT DFW&P is based on species and is applied through objectives placed on various waters. Semi-annual surveys recorded in the DFW&P Fisheries Division provide the following information.

Upper Red Rock Lake is closed to fishing and contains grayling, cutthroat and brook trout, burbot, longnose sucker, and white sucker. Fish biomass in 80-90% of potential. Sport fish growth rate is fair and condition is good. Factors limiting the fishery are temperature, shallow water level, oxygen depletion, excess siltation, and watershed abuse by stock overuse. Siltation of Upper Red Rock Lake will eventually eliminate fish. Beaver dams arguably present barriers in the inlets to the streams. Management recommendations are to manage for wild fishery, trophy fish, unique species, renovate the watershed, dredge to deepen the lake, and increase natural spawning of cutthroat trout.

Lower Red Rock Lake has white sucker and burbot listed as common; Arctic grayling is uncommon or rare. Sport fish growth rate is poor but condition is good. Habitat rating for grayling is limited. Factors limiting the fishery are siltation and stock overuse. Fish populations are limited by minimal depth of lake (avg. max. depth = 2 m).

McDonald Pond is managed for trophy rainbow trout. Other fish species present is the White Sucker. Fish biomass if 60-70% of potential. Sport fish growth rate is fair and condition is good. Fishing pressure in 1976 was 860 man-days/year which represents 70-80% of allowable pressure. This is a man-made lake. Factors limiting fishery are mostly natural -- barriers in inlet blocks Elk Springs Creek and reduces spawning habitat. Management recommendations are to manage for wild, trophy fish and increase natural spawning of rainbow trout.

Culver Pond is managed for trophy brook trout. This is apparently the only species present. Fishing pressure in 1981 was 1000 man-days/year. This is a natural lake supplemented by man-made structure. Factors limiting fishery are excess water level fluctuations (up to 2 m annually). Management recommendations are to manage for the wild, trophy fishery.

Elk Lake has Arctic grayling, lake trout, cutthroat trout and white sucker, all common. Burbot and longnose sucker are uncommon. Fish biomass is 50-60% of potential. Sport fish growth rate is fair and condition is good. Cutthroat trout are regularly planted. Fishing pressure in 1975 was 339 man-days/year representing 50-60% allowable pressure. Factors limiting fishery are lack of spawning area and barrier in inlet. Management recommendations are manage for wild fishery, especially unique species. Study planting improvements.

Increase natural spawning of grayling. Flow in Narrows Creek is key to survival of grayling population -- augment flow.

The upper 13 kilometers of O'Dell Creek (headwaters to Hwy 287 bridge) has brown trout, white sucker, mottled sculpin, longnose sucker,and long nose dace commonly occurring, rainbow trout, mountain white fish are uncommon and the Utah chub is rare. Fishing pressure in 1982 was 322 man-days/year/10 km. Factors limiting fishery are watershed abuse by overgrazing by livestock and bank encroachment by livestock trampling. Reach is a spring creek of highest habitat value but trend is deteriorating. All private land, stream is used to water livestock.

Lower O'Dell Creek, from refuge boundary to lower Red Rock Lake, has abundant longnose sucker and white sucker. Arctic grayling are common. Cutthroat, cutthroat and rainbow hybrids, and brook trout are uncommon. Mountain whitefish are expected but were not detected. Fishing pressure in 1982 was 432 man-days/year/10 km. Habitat trend is static. Factors limiting fishery are lack of spawning area, inadequate riffles, bedload movement, highly erosive drainage, turbidity, and low density of aquatic invertebrates. Man-caused perturbations are excess siltation and de-watering for agriculture. Overuse by stock abuses watershed. This is an important spawning tributary.

Red Rock Creek below upper Red Rock Lake has burbot and grayling listed as uncommon. Brook trout, cutthroat trout, longnose sucker and white sucker are all expected but undetected in survey. Fishing pressure in 1982 was 466 man-days/year/10 km. No factors listed as limiting the fishery. Habitat trend is static.

Red Rock Creek from Hell Roaring Creek to Upper Red Rock Creek has abundant spawning grayling and cutthroat trout. Brook trout are common and the mottled sculpin was expected but not detected. Fishing pressure in 1982 was 466 man-days/year/10 km. Habitat trend is deteriorating. Factors limiting the fishery are excess siltation and watershed abuse by stock overuse. management recommendations are to conduct surveys. This is an important spawning tributary, perhaps the most crucial for both grayling and cutthroat trout.

Red Rock Creek from the source to Hell Roaring Creek has grayling occurring as uncommonly and for spawning. Rainbow and brook trout were expected but not detected. Fishing pressure in 1982 was 466 man-days/year/10 km. Habitat trend is static. Factors limiting fishery are over use by stock and bank encroachment by stock trampling. Management recommendations are to stabilize the banks.

Tom Creek has grayling occurring rarely in the lower reach

for spawning only. Brook trout are common in upper and lower reaches. Factors limiting fishery are mostly natural: inadequate pools, excess flow fluctuations, and lack of bank cover. Water is removed for agriculture and the bank is encroached by livestock trampling. Management recommendations are to improve bank cover, stabilize the bank and remove excess debris.

Hell Roaring Creek has cutthroat trout listed as common. Brook trout are uncommon and grayling are expected but were not detected. Habitat trend is static. Factors limiting the fishery are steep gradient and temperature in upper reach, fish barrier, stock trampling and culvert barrier in the lower reach. This is an important spawning tributary which receives heavy use for stock water.

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David Genter, Zoologist
Montana Natural Heritage Program
1515 E. 6th Avenue
Helena, MT 59620

MONITORING OF THE CENTENNIAL MOUNTAINS AND VALLEY ECOSYSTEMS

VEGETATION

Optimally, the most common communities within each of the vegetation types (aquatic, wetlands, lower to mid-elevation grasslands, mid to high elevation meadow, sagebrush, sandhills, and forest types; Fig. 1) should be monitored to obtain baseline data for the ecosystem. Within each general vegetation type, many communities are represented -- many of which are as yet technically undefined. Determining the most common communities, if not known, could be done initially from survey of color and infra-red aerial photographs and by field inspection. Additional sites should be monitored if deterioration is noted (streambanks), or little is known about the processes maintaining that community (sandhill blowouts). Standard (for cross-referencing) and special monitoring techniques (for answering specific questions) should be employed for the additional sites.

METHODOLOGY

Standard methods of monitoring range ecosystems include canopy cover estimates (Daubenmire, 1952), point intercept (Mueller-Dombois, 1968), population studies (Harper, 1970), and annual production measurements (SCS, 1967). Production measurements are currently the most widely used technique in Montana range studies. Ten 1 m2 circular plots are clipped at ground level, species sorted and correctly identified, dried, and then weighed. Total production for the site is expressed as an average of the 10 plots in #/acre, and species composition is expressed in terms of relative % #/acre. Sources of error in this technique include not clipping at ground level, incorrect identification of species, and differences in the plant phenology at time of clipping. If biomass samples could be stored frozen after separation, drying, and weighing, then data could be rechecked if species or weights were in question. Standardizing the timing of clipping could be done by monitoring leaf length of dominant species (such as Agropyron spicatum or Festuca idahoensis) and clipping the week after maximum length is obtained. This would standardize between vegetation types and between years. Although labor intensive and therefore costly, monitoring vegetation by the production method has the potential to be the most accurate, standardized between scientists and years, and compatible with other data sources within the region. Range sites should be monitored yearly.

Other methodology should not be ruled out without consideration. Canopy cover estimates are non-destructive, relatively fast, and inexpensive. However, there is no way to control for errors in species identification, differences in estimates between observers, or years. If cover estimates were

used as the main method of monitoring, photographing permanent plots is recommended to augment the data. The point intercept method is also non-destructive, but is more time consuming than the cover estimates (for a simple grassland, over 3000 points should be used). Population studies are very labor intensive, but are recommended for special site monitoring for the streambank, sandhill, and ecotone sites. This technique consists of at least 5 1m x 1m permanent plots, with a way to determine exact location of seedlings and mature plants on a seasonal and yearly basis. This may be achieved by a set up consisting of two plexiglass plates, 1m x 1m, with a 1 cm grid on each. The grids are matched up in line of site, and coordinates of individual plants are recorded. Alternatively, plastic can be laced over the top plexiglass sheet and locations of plants marked with permanent pens (Mack, pers. comm; Harper, 1970). This is not feasible when it rains, or there is high plant density. In this way, the fate of individuals can be followed through the season (mortality rates) and recruitment of new individuals can be monitored. This would allow determination of which species are critical and would allow mathematical modelling of the population.

The standard technique for measuring forest stands has been carefully described by Greene (1984). This includes a permanent 100m x 100m sample plot, line transects for the shrub layer (100-120 m recommended), with 100 20 cm x 50 cm plots placed systematically for the herbaceous layer. Forest plots should be sampled every five years.

PRIORITIZATION OF MONITORING

The International Biological Programme standardized large scale ecosystem studies in the early 1970's. Each component of the ecosystem was identified (topography, geology, soils, microclimate, hydrology, flora, vegetation, system processes and dynamics, and system modelling) and then systematically studied. The following is a list in order from most to least critical to monitor: streambank communities, sandhill blowouts, wetlands, sagebrush/grassland ecotone, Douglas fir/grassland ecotone, and subalpine fir/subalpine meadow ecotone.

The most critically endangered component of the ecosystem is water quality, and stream bank erosion contributes to a deterioration of water quality. A grass-dominated versus a sage-dominated streambank is more susceptible (BLM, 1980), and thus should be used in monitoring. The priority would be to determine the stability/instability of grass-dominated streambanks. A population-based study would be required with community-level studies of secondary importance for cross-referencing with other studies.

The sandhill blowouts are of second priority in the

Centennial study area. The priority would be to determine the maintaining mechanisms for blowout structure and community composition. A population level study would be required with special attention paid to rare plant population dynamics. Community-level studies would be of secondary importance.

The wetland communities are the most productive of the area (3000 + #/acre; Tippy, et al., 1978) and as such, represent an important resource. From aerial photographs, the wetlands appear to be one of the more manipulated vegetation types in the Valley. Production levels of the most common wetland community (Carex spp. dominated?) in an undisturbed and disturbed site should be monitored. A population-level study would be required only to determine the role of irrigation in converting low elevation grasslands to willow thickets. Since the land area affected appears to be small, this would not currently be a priority.

Ecotone studies of the sagebrush/grassland and the Douglas fir/grassland is of moderate priority to determine whether or not shrubs or trees have invaded the grassland, and how the shrub and forest vegetation types should be managed. This study could be handled entirely at the population level (Cotter, 1951), with supporting soils studies. However, it would be relatively cost-effective to simultaneously run long-term community-level studies to augment population work and provide for compatibility with other studies. An ecotone study between the subalpine fir and subalpine meadow is of moderate priority to determine the long-term climatic stability in the Centennial area.

The lower to mid-elevation grassland probably represents the second most important vegetation resource in the Centennial Valley, and as such should be monitored for production and species composition. Because grasslands are relatively resilient to disturbance, they have not been placed in a higher priority. Permanent plots should be set to determine long-term stability in production and species composition in undisturbed (control) and disturbed sites. The following production studies would be necessary for a complete ecosystem study, but should be low priority: high elevation grassland, rocky slopes and cliffs.

RARE PLANTS

Nineteen species of 'special concern' were identified in the Centennial Mountains and Valley. The first priority for monitoring is to determine actual location of all 19 species, and determine whether or not they are indeed regionally or globally rare. In order to prioritize research without further information, we must assume that species which occur in multiple habitats (i.e., wide elevation ranges, grasslands, shrublands,

and forest) or in habitats which get little use or are naturally protected (i.e., talus slopes) have lower priority. Species which occur in unstable habitats (streambanks, sandhills) or highly manipulated habitats (seasonal wetlands) are perhaps the most likely to be endangered. This reduces the list to nine top priority species. Species were ordered from most to less critical habitat (streambanks>sandhills>wetlands), and within the habitat from plants that reproduce by seed to those which vegetatively reproduce. The following species have been ranked from highest to lower priority for research: 1) Carex multicostata; 2) Equisetum palustre; 3) Cryptantha fendleri; 4) Astragalus ceramicus; 5) Oenothera pallida; 6) Leymus flavescens; 7) Thelypodium sagittatum; 8) Senecio debilis; 9) Kobresia simpliciuscula. The remaining species could be ranked using the same approach.

METHODS

Once prioritized, rare species require intensive, population level monitoring. Monitoring would include flux of population size by age or size classes (mortality/survival rates), and calculation of reproductive effort: (population density) x (proportion of population of reproductive age) x (proportion of population flowering) x (# of flowers per reproductive plant) x (# seeds produced per flower) x (proportion of viable seeds) = (reproductive effort, in # of viable propagules/m2) (Grulke and Bliss, 1985). This technique has been used for annuals (Reynold, 1984; Hickman, 1975), and perennial forbs and graminoids (Law, 1981; Callaghan, 1976). With modification, rhizomatous grasses (Lawrence, et al., 1978; Allesio and Tieszen, 1975) and tussock or bunch grasses can be monitored (Chester and Shaver, 1982; Fetcher and Shaver, 1982). This allows close, mathematical monitoring of rare species on a yearly basis. Although plot size depends somewhat on the size of the plant, 100 20cm x 20cm plots are recommended for relatively simple communities such as the streambank, sand dunes, and wet meadows. Communities with greater species richness or microenvironmental variation might require additional plots.

FAUNA

Proposed is a monitoring program to identify patterns, recognize long- and short- term trends and deviations from the norm of select vertebrate species and invertebrate groups. Taxa suggested for monitoring are indicators of the system and provide quantitative data for assessing the ecological health of the system.

Four design elements have been identified as essential to an ecological monitoring program (Bell and Atterbury 1983, Likens 1983, Verner 1983): 1) long term to account for variability; 2) statistically valid and sensitive to trends; 3) ecologically

appropriate; and 4) cost effective. Monitoring ecosystems is not a short term endeavor meant to solve a temporary problem. Likens (1983) identified monitoring as a continuing objective with an overall purpose of learning enough about a system to formulate meaningful and testable questions. Statistical considerations center on detecting and comparing change over time, and adequately dealing with replication, sample sizes, and stratification. Non-parametric analyses are often more appropriate (Halvorson 1984).

Ecological appropriateness (Hinds 1983) requires that assumptions about ecological relationships are valid. Halvorson (1984) discusses the problem of confusing species associations for dependency in the literature and noted that recognition of the difference was rare. Perceived (rather than proven) relationships are often the case and are frequently incorporated into habitat models. For common species it is possible to accurately predict presence/absence, or even their abundance, from secondary indicators such as vegetation type or structure. But rare species are more sensitive to environmental limitations and there is a need for precise knowledge, beyond an association, of their needs (Jenkins 1977).

Cost effectiveness is often the limiting factor in designing monitoring programs and often influences study design. If monitoring is a continuing program that emphasizes species inventories and population trends, then the decision risk is low and allows for simplistic techniques (Halvorson 1984). Monitoring rare species for environmental assessment can be costly in many cases. The relative costs of detecting common versus rare species is analyzed by Marcot et al. (1983).

Monitoring is proposed and described for seven vertebrate species and aquatic macroinvertebrates on two streams. These taxa are either threatened or endangered (bald eagle, peregrine falcon), rare and of special concern (trumpeter swan, Arctic grayling), or indicator species with narrow ecological amplitude (dipper, pocket gopher, mottled sculpin, aquatic macro-invertebrates).

Extensive monitoring on reproduction of the bald eagle, peregrine falcon, and trumpeter swan already has been established through interagency coordination. These surveys primarily investigate fledgling success of each nest and location of new nest sites and territories. Hack site activity and fledging success for captive-released falcons are monitored by the Peregrine Fund and information is provided to the Red Rock Lakes National Wildlife Refuge. These data are readily available although publication of nest site locations of sensitive species such as the falcon and eagle is discouraged.

Monitoring of the Arctic grayling has been sporadic in time

and space. The Fisheries Division of MTDFW&P has conducted censusing in nearly all streams and lakes in the valley (G. Holton, pers. comm.). This has been supplemented by grayling studies conducted by Nelson (1953a, 1953b), Gibbons (1964), McLauroy (1966), Vincent (1963), and Lund (1974).

A comprehensive monitoring program on grayling was initiated in 1985 by the USF&WS (B. Reisweig, pers comm.). This will be annual monitoring but of unknown duration. Radiotelemetry and capture release techniques will be used on Red Rock Creek. Spawning surveys will be conducted on O'Dell Creek. Also environmental conditions of Upper Red Rock Lake will be measured during the winter to assess their role in limiting grayling populations.

Stream monitoring is proposed for benthic macroinvertebrate communities on Red Rock Creek and O'Dell Creek. Population trends, taxonomic composition and diversity of the stream fauna provides a direct assessment of habitat quality and stability (Ward and Stanford 1979, Weber 1973). Yearly monitoring of invertebrates will allow a more immediate evaluation of conditions throughout the planned watershed management activities.

Benthic invertebrates can be collected from approximately ten stations on each stream with modified Hess samplers (Hughes 1985, Canton and Chadwick 1984). Samplers enclose 0.1 sq. m and have a collecting net with a mean mesh size of 700 microns. Three samples from each station should be collected in late September. Samples are preserved in 95% ethanol and sent to a lab for sorting and identification. Samples should be keyed to the lowest practical taxonomic level. The EPA encourages the use of the Shannon-Weaver diversity index as a measure of the effects of stress or change on benthic communities (Weber 1973).

Analyses used by Canton and Chadwick (1985) allowed testing between stations and years. Additionally, Whittaker (1975) suggests using cluster analyses with two similarity indices -- the Coefficient of Community which measures similarity in terms of the presence/absence of species and Percentage Similarity which measures similarity using relative abundance of like species. Further details on other field and laboratory methods for stream and lake surveys may be found in Weber (1973).

Yearly surveys of the mottled sculpin (Cottus bairdi) in streams can provide direct monitoring of habitat quality. Sculpins (Family Cottidae) are small fish that require well oxygenated waters with gravelly substrates (Brown 1971). They provide an important food source for resident trout but are impacted by severe siltation. Biological monitoring of fish and population estimates are provided in Holcutt and Stauffer (1980). Vincent (1971) describes electrofishing techniques and their use

in estimating populations. Because sculpin stay close to the bottom and are more difficult to sample, kick net and electroshocking techniques should be combined for sampling.

Dippers (Cinclus mexicanus) are our only truly aquatic songbirds. They live along mountainous streams and feed on aquatic invertebrates (Terres 1982). Their unique habitat requirements, dependence on aquatic insects, and relative ease of censusing make them ideal for environmental monitoring. These birds will appear in the spring and follow the ice melt up into the headwaters. Methodology for censusing birds is covered in Ralph and Scott (1981), which is considered to be the primary reference for any bird monitoring program.

The pocket gopher (Thomomys talpoides) is an adaptable species, occupying a wide variety of soil and vegetation. It is absent in areas of low ground cover and extremely rocky or moist soils. Shallow snow cover affords them little protection from severe freezing and they will avoid such areas in winter. Pocket gophers do not go through the extreme cyclic population levels that characterize microtine rodents. Their relatively stable populations and response to vegetation disturbance make them useful subjects for monitoring small mammals in grassland habitats.

Relative abundance for pocket gophers can be compared with indirect counts (Anthony and Barnes 1982, Reid et al. 1966). Halvorson (1984) outlines a system of measuring pocket gopher density by using indirect counts based on 0.05 ha circular plots. Pocket gopher mounds are flattened and after a 48 hour period any new digging evidence is counted as an active plot. Relative density is expressed as the number or percent of plots having sign. Plots are spaced at 15 m along a transect, a distance reasonably assumed to separate individuals. Plot area should represent at least 5% of the site. Sampling is best done in late summer when activity is high and young are dispersing.

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Nancy Grulke, Plant Ecologist
Steve Shelly, Botanist
David Genter, Zoologist
Montana Natural Heritage Program
1515 E. 6th Ave.
Helena, MT 59620